The Wilbur and Orville Wright Memorial Lecture
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by
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President Pardoe, distinguished guests, ladies and gentlemen:

I am extremely pleased to be here and very proud, indeed, to have been invited to give the Wilbur and Orville Wright Memorial lecture this year. I want to thank you all for this great honor.

The other day, I was rereading the list of lecturers and the topics they have addressed over the years since this annual lecture series began in 1913. It occurred to me that the list is a remarkable reflection of the history of aviation and aerospace technology and, as such, symbolizes the rapid and dramatic progress of flight since Kitty Hawk.

As an old Navy man, I was particularly interested to see that in 1921, the lecture, entitled "Naval Architecture in Aeronautics," was delivered by Dr. Jerome C. Hunsacker, then a United States Navy Commander. Dr. Hunsacker, as you well know, was a great aviation pioneer and one of the world's leading theorists of flight and aircraft design. He founded the first college course in aeronautical engineering at the Massachusetts Institute of Technology and developed the first model wind tunnel in the United States.

Dr. Hunsacker died three months ago at the age of 98. He once was reminiscing about the early days of flight studies at M.I.T., and I believe his words are worth recalling today because they give us an idea of the long and difficult path we have taken in the history of human flight.

"In the beginning," he said, "it was not possible to teach the principles of aeronautical engineering because none of us knew them. The principles had to be discovered, which meant that we had to investigate the difficulties of the past, collect a lot of facts, and then, after finding the meaning of the facts, determine the engineering principles of flight."

That was a formidable task indeed. That it succeeded is a tribute to the persistence and imagination of Dr. Hunsacker and others like him on both sides of the Atlantic—many of whom belonged to this society—who probed the frontiers of the unknown with courage, conviction and skill.

We will never forget the daring of such British airmen as Alcock and Brown, who made the first non-stop trans-Atlantic flight in 1919; or the stoic heroism of Major Scott, who flew in a dirigible that same year from Scotland to New York and flew back to England four days later after his 90 hours aloft.

The efforts of these and other pioneers in aeronautical engineering have, indeed, transformed our lives. They spawned an era of rapidly accelerating change that has brought us from the dunes of Kitty Hawk to the routine access to space we enjoy today with the Space Shuttle—all in the span of a human lifetime.

Next Monday, we will celebrate the 81st anniversary of the birth of powered flight, the culmination of the Wright Brothers' often frustrating and lonely efforts. But, as Winston Churchill once said: "Solitary trees, if they grow at all, grow strong."

The tree of human flight the Wright Brothers planted on the dunes of Kill Devil Hill has, indeed, grown strong. Today, Orville's entire first flight, both in distance and in altitude, could easily be contained in the cargo bay of a C-5 Galaxy. But from the Wrights' small beginning we have learned to fly farther, faster, safer and more efficiently than the Wright Brothers ever could have imagined.

No one area of human endeavor so dramatizes this era of rapidly accelerating change in which we live than the progress of flight since Kitty Hawk. It has given us the means to travel to the most remote areas of the

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globe. It has taken us to the moon and provided us with reliable access to and from near-earth space with the Space Shuttle and the Space Transportation System.

Today we are moving to take the next logical step in the evolution of human flight—and I believe, in our cultural and technological evolution as well—by developing a permanent human presence in space—a permanently-occupied Space Station.

Robert H. Goddard, the great American rocket pioneer, once said, "Real progress is not a leap in the dark, but a succession of logical steps." Looking back on the history of human activities in space, we can see how right he was. From Mercury, and on through Gemini, Apollo, Skylab, and the Space Shuttle, we have been moving steadily into larger, more ambitious programs. Each has been a logical and rational extension of what came before. And each has been built on past experience.

The Space Station will be no exception. When it is operational in the early 1990s, it will be the culmination of all of our efforts to expand human activities in space, and indeed, central to those efforts well into the 21st century. The Space Station will open a whole new universe of opportunities which we will be able to pursue for scientific, industrial and commercial gains. Thus, it will help to set our course in space for generations to come.

History has taught us that the process of pushing back frontiers on earth begins with exploration and discovery, which are followed by permanent settlement and economic development.

The lonely explorers like Ronald Amundsen, Robert Scott and others who endured the rigors of Antarctica in the early decades of this century are analogous to our space pioneers today. And just as the airplane opened Antarctica to permanent human habitation, so will the Shuttle and the Space Station open space to a limitless range of opportunities as a permanent home for mankind.

Indeed, civilization's expansion into space already has begun. The frontier has been breached with the Space Shuttle. We are on the verge of putting down permanent roots there with the Space Station. And essentially, there is only one way to go from there—forward—in ways we have not been able to go before—to the moon, to the asteroids, to Mars and to other planets and beyond. And these voyages will be only the beginning.

The only limits we will have are those of our imagination. And imagination has proved to be a powerful force in human affairs.

Almost 100 years ago, the New England clergyman, novelist and lecturer, Henry Ward Beecher called imagination "the secret marrow of civilization . . . the very eye of faith." Indeed, all through history imagination has been the wellspring of the fundamental human drive to explore, to find new knowledge and to discover and settle new frontiers.

Imagination has helped to pave new paths in technology and to chart the course of science. It has nourished great art and literature and opened the way for civilizations to grow and prosper. And, perhaps most important, it has been intimately connected with the notions of freedom and self-fulfillment that we in the democratic world hold so dear.

Small wonder, then, that those nay-sayers and disbelievers who have ignored imagination and its potential to shape our destiny leave only a few, faint footprints on the sands of history. Let us look briefly at just two examples.

More than a century and a half ago, there were the Luddites. More recently, there was the Club of Rome. Both fortunately were short-lived.

The Luddites flourished here in Britain from about 1811 to 1816. They were organized bands of masked men who believed that the coming of machines early in the industrial revolution meant that people would be put out of work permanently. They vented their rage by going about the country destroying machinery used mostly in the textile industry.

The cultural heirs to the Luddite tradition sprung up in the early 1970s. The people of the so-called Club of Rome sounded the alarm that there are limits to growth and progress because our global resources are finite.

I'm sure you remember their conclusion that the only way to deal with limits to growth and limits to progress is to divide the pie among people so that each would get his share that never grows. Who would divide that pie?

The implication was clear: the members of the Club of Rome, of course, who believed they had the knowledge and intelligence to set an agenda for a world that would allow them to gain power.

The fundamental error made by the Luddites, the Club of Rome, indeed, by the Malthusians and others who have shared their philosophy, is one of forgetfulness. They forgot to remember that the human imagination is not finite.

And as long as we are free to imagine what the future might be like and to work toward it, there are no limits. For me, this is the very real meaning of our enterprise in space.

The Space Station and the activities it will promote in space will not only stimulate our imaginations to do new things in new ways, but will enable us to do all of the things we have been dreaming of doing since the dawn of the space age, and, perhaps, things we have not yet dreamt of.

It has been argued, and rightly so, in my view, that technology is the driver of science. Without the telescope, for example, Galileo could never have discovered the Jovian moons. Without the microscope, Pasteur and other microbe hunters could never have made their observations and discoveries which have been of so much benefit to mankind.

Even Einstein owes a debt to technology. The foundations of his theories on relativity and quantum mechanics were laid by Michael Faraday's experiments on electricity and magnetism—experiments which led to James Clark Maxwell's discovery of electromagnetism. Einstein kept Maxwell's photograph above his desk and freely acknowledged his debt to him in his scientific papers.

High technology, and in particular, aerospace technology, not only drives science, but has already given birth to tens of thousands of applications and spin-offs, as we like to call them, to benefit our lives on earth. In the medical field alone, many of these applications, such as CAT scanners and programmable heart pacemakers, are helping to improve the quality of life and even to prolong it.

The new Programmable Implantable Medication System, for example, is an important medical breakthrough that stems almost completely from aerospace technology. When implanted within the human body it dispenses the exact amount of medication patients need when they need it. The system promises to revolutionize treatment of such diseases as diabetes, hormone dysfunction, cancer and others in which precise amounts of medication over a period of time are essential.

In Shakespeare's "Two Gentlemen of Verona," Antonio says, "Experience is by industry achieved, and perfected by the swift course of time." There is no question that the new technologies we will perfect as we continue to advance across the aerospace frontier will spawn even greater benefits in the future both on earth and in space.

The advanced technologies we will employ on the Space Station will spur scientific exploration of the solar system and the universe by both manned and unmanned vehicles. They will invigorate earth applications and the study of earth as a global system. And they will stimulate sustained research and development on innovative systems and techniques.

With the Space Station and family of automated and semi-automated space transportation vehicles we will develop with it, we will be able to service satellites in orbit, and thus prolong their scientific and commercial utility.

We will be able to use the microgravity environment to develop any number of promising manufacturing enterprises, such as making pure crystals for electronic components, new alloys for industry and new medicines to help fight such diseases as cancer, diabetes and hemophilia.

Moreover, the Space Station will give us a staging base for future, more ambitious missions, such as a return to the moon to establish a permanent base to mine lunar resources; or a manned expedition to Mars.

The two key elements of the Space Station's supporting infrastructure that will enable us to plan realistically for such advanced missions will be the vehicles I spoke of just a moment ago. They will be true reusable spaceships because they will be designed to operate only in space—in low earth and at geostationary orbits and between them; and eventually at distances as far as the moon and the inner planets.

First to come on line will be the Orbiting Maneuvering Vehicle, or OMV. It will be used to service satellites close to the Space Station and for other tasks, such as assembling large structures, such as communications antennas, or an array of large telescopes.

Following the OMV will be the Orbital Transfer Vehicle, or OTV. It will be used to ferry payloads to and from near-earth orbit to geosynchronous orbit, or to launch spacecraft to other points in the solar system.

As we move out farther away from earth, to higher orbits and, perhaps, to other worlds, it is clear that this expansion will pose great challenges, both to our imaginations and to our resources.

Enterprises of the magnitude and scope of a manned lunar base or a manned mission to Mars, for example, would require not only the development of new technologies, but of management techniques and economic analyses that would make them both feasible and profitable. This implies even greater international cooperation and international sharing of both risks and benefits in the future.

And this brings me to a key point, one which we must begin to think about now, if we are ever fully to reap the potential benefits of space for all mankind. I believe that for civilization to expand into space, humanity must also be prepared to expand international cooperation.

We must build a solid framework for space ventures that transcends rivalries between nations or groups of nations. And we must begin to build that framework now, here on earth, so that the best minds, wherever they may be found, will work together, not for years or decades, but for centuries, to use space in the most productive, economical and rational ways we can.

International cooperation in space is not a new concept. It has been a basic principle of the United States' space program since its inception. The 1958 National Aeronautics and Space Act, which created NASA, directed the agency to cooperate with other nations in space activities and to share the benefits of space research.

This policy has been reaffirmed by each of the seven American Presidents since then, and most recently by President Reagan. In January of this year, the President directed NASA to develop a permanently manned Space Station within a decade. At the same time he invited our friends and allies to join with us in the Space Station program.

The President's invitation underscored his convictions that an international Space Station will provide a focal point for space operations well into the 21st century, and that international cooperation in this program can be mutually beneficial to both the United States and its partners.

Through the years, the United States has had more than 1,000 agreements with some 135 countries and international organizations, covering activities ranging from major hardware contributions to ground-based studies and data analysis. Today, virtually every NASA space project has international involvement.

You probably are well aware of some of our recent successful cooperative programs, such as the Infrared Astronomical Satellite, conducted with the United Kingdom and the Netherlands; the Active Magnetospheric Particle Tracer Explorers project, operated with the United Kingdom and the Federal Republic of Germany; the multilateral Satellite-Aided Search and Rescue System; and major contributions to the Space Shuttle program, such as the European Space Agency's Spacelab and the Canadarm, or Remote Manipulator System.

Taken together, these projects have expanded both the resources and capabilities of participants and have allowed each partner to do and learn more than it could alone.

Now, I do not mean to imply that this type of cooperation in space has been applauded universally. It has had its critics. And most of them would agree with Agatha Christie's observation that, "Where two people are writing the same book, each believes he gets all the worries and only half the royalties."

Nevertheless, as Agatha Christie must have known, such partnerships, linked by shared values and shared goals, can be very beneficial to all concerned.

Even most critics of international cooperation in space agree that by sharing scientific expertise and data from our joint missions we have not only expanded the knowledge base, but also have served the cause of international understanding and, ultimately, of peace.

For we have learned that joint undertakings in space foster cooperation, rather than

confrontation; and thus, offer a viable alternative to war. Indeed, I believe that as we go on to even greater challenges together, international ties will be strengthened and the prospects for long-term peace will improve.

So we have ample precedent for international cooperation in space, and a firm base from which to build a framework to expand joint activities in the future. There are indications that our friends and allies on the Continent, and in Canada and Japan will soon accept President Reagan's invitation to collaborate on the Space Station. I hope and believe that Britain, too, will join us in this magnificent new venture.

We welcome such potential cooperation, both in the development and operation of the station, and are confident that it will serve the ends of our partners and ourselves, programmatically, technologically, politically and economically.

In this connection, our own planning for industry's participation in Space Station activities is progressing rapidly. President Reagan has made it clear on several occasions that one of his top national priorities is to create a climate that will move industry into space quickly and with confidence.

Under the President's national space policy, government is working to foster the growth of commercial expendable launch vehicle operations and to increase private sector investment and involvement in space operations. Laws and regulations that would obstruct such activities will be updated or eliminated to clear the path for industry's access to space for the long term.

Our intention is to forge a strong government-industry partnership to expand and nourish private sector enterprises in space. Such a partnership has many precedents. There is a long American tradition of fostering economic growth and progress through governmental initiatives. Government-industry partnerships helped to build our highways, railroads and airport and airways system. Now they will help to move us across the final frontier of space.

Even as we move to expand industry's role in space activities, we are cooperating in every possible way with our friends and allies to assure that they will be in a position to participate fully in the Space Station program.

In discussing participation in the Space Station development program with our potential partners, we have made no secret of the fact that if they were to be committed it would have to be for the long haul.

We seek associates who are prepared to make significant investments and who will use the station after helping to build it. We want partners who will continue to shoulder responsibility for owning and maintaining their portions of the facility, while continuing to enjoy the overall benefits our joint labors will make possible.

To cement this long-term relationship, we are prepared to provide our colleagues with assurances on access, protection of technology and intellectual property and suitable roles in the Station's management and operation.

The Space Station will grow and evolve as new needs develop, and the effort will span decades. It will be the largest and most difficult international project of the space age. By learning to work together on a project of this scope, we will be laying the groundwork for even more extensive joint efforts in the future.

Indeed, projects such as the development of a manned lunar base or a manned mission to Mars might well be the logical extension of our Space Station activities. And missions of that dimension might even tempt the Soviets to join with us. If that should happen, it would certainly enhance the long-term prospects for peace, both on earth and in space.

Even before the Space Station was approved by the President and by Congress, NASA opened its planning process to a number of potential international partners. Participants agreed to undertake parallel planning studies in tandem with ours. And we agreed to exchange results. It was understood, however, that participation in this early planning phase implied no commitments to participation in future phases.

The results of the parallel mission requirements studies conducted in Europe, Japan and Canada were compatible with those of NASA and were factored into our planning. Thus, by looking at user requirements across the board, together we evolved a "form-follows-functions" principle, which ultimately will determine the Space Station's design and will serve both American and international interests.

Bernard Baruch, the American financier and Presidential adviser, wrote: "The highest

and best form of efficiency is the spontaneous cooperation of a free people." The same principle applies to this early joint international interaction. I believe all involved profited from this process in several ways.

In studying potential user requirements, both we and our potential partners took a fresh look at our long-term objectives in space and dealt with members of both the aerospace and nonaerospace communities.

We also were able to reassess the value of man's presence in space and the commercial potential of space processing and operations, subjects intimately linked to Space Station planning, development and utilization.

It was no surprise that our potential partners' mission requirements studies reflected their respective experience in space operations.

Western Europe, for example, has been looking at pressurized modules and platforms based on their Spacelab and Eureca/SPAS experience. Canada is very interested in expanding its experience with the Remote Manipulator System in the servicing and payload handling area. And Japan, which developed experimental equipment on Spacelab, appears to want to pursue a pressurized laboratory and platform to conduct experiments identified in their mission studies.

This two-year international planning exercise was unique and the results have been exciting. We now have an expanded knowledge base for going forward into the definition and developmental phases of the Space Station. And equally important, all participants have had an extended opportunity to evaluate cooperative possibilities, to assess their own self-interest in proceeding and to build trust and confidence in each other's capabilities and good intentions.

The new phase of the Space Station program is underway and will last through 1986. It will define the design and initial parameters of the station. Although the United States is committed to going it alone, if necessary, we are delighted that our potential partners seem ready to continue their studies to define their elements of the program as well. And we look forward to continued joint cooperation as the program develops.

I believe it was Euripides who wrote: "Joint undertakings stand a better chance when they benefit both sides." This philosophy has guided us in negotiations on international participation in the Space Station and will continue to guide us as we move forward.

Our goal is to make the Space Station a true and highly visible symbol of international cooperation in space, and a place where men and women of many nations can live, work and learn. While some may want to focus on the risks inherent in undertaking a collaboration of this scale—and, indeed, they exist—I believe there are much greater risks in not making the effort—in failing to try. Only by taking the next great step together can we truly keep alive the splendid possibilities that await our joint endeavors.

For our long-term vision is to create conditions for the most creative brains on earth to work together in the great adventure of exploring the universe, not only in the coming decades, but for centuries to come.

In Shakespeare's "Love's Labour's Lost," Biron says, "Learning is but an adjunct to ourself. And where we are our learning likewise is."

I believe that the learning that has spawned all of the creations of modern civilization—from the suspension bridge and the skyscraper to the computer and the Space Shuttle—grew essentially from mankind's urge to breach the limits of the unknown. Thus, these creations express not only the cutting edge of our technological skills, but the deepest yearnings within us.

And, as such they represent a synthesis of technology and humanism, a melding of our highest technical capabilities and of the deepest impulses in our nature.

Twenty-five years ago, C.P. Snow warned of an unbreachable "gulf of mutual incomprehension" between humanists and scientists in his famous Rede lecture, "The Two Cultures and the Scientific Revolution." Today, Snow's two cultures are merging in the wake of our technological evolution.

What will this development mean for our future?

Earlier I called the Space Station the next step in our cultural as well as our technological evolution. Indeed, I believe we cannot continue to expand into space without continuing to grow as human beings.

The impact of Charles Lindbergh's solo flight across the Atlantic almost 58 years ago was felt around the world. In a frivolous decade, it stirred our imaginations and was the catalyst for the rediscovery of old virtues, such as bravery, solitary discipline and applied knowledge.

Forty-two years later, with the Apollo 11 mission, two humans walked on the moon for the first time. Their voyage expanded our view of the human potential, extended our capacity for awe and created a new sense of confidence that the human race could, indeed, control its own destiny.

Today we go into space routinely and dream of returning to the moon and going to Mars to build permanent human settlements. As President Reagan said at the Goddard Space Flight Center in Maryland back in August, "Each technological breakthrough enables us to work from a higher plateau of knowledge."

And I believe that as we continue to ascend those plateaus, we will continue to unleash the energy, creativity and imagination that break the barriers to progress and allow free people to go as high as their aspirations will take them.

How often have we heard the expression, "if we can go to the moon, we can do just about anything we set out to do." Our wish list is long, indeed: eliminate poverty, conquer ignorance, vanquish disease, destroy oppression—in fact, devise an antidote for all the poisons in the human system.

Today, these poisons are still very much with us. But we know for each there is an antidote. And today, for the first time, thanks, in part, to space technology and its spin-offs and applications, the antidotes are within our reach.

We have the knowledge and the means of distributing it to vanquish ignorance.

We have the medical technology to wipe out many of the diseases that were once deemed hopeless.

We have the economic strength and technological expertise to combat poverty, if we chart the right course and stick to it.

And oppression will surely yield to freedom—gradually and inevitably, in a stable peaceful and open world, where people can compare and ultimately choose for themselves.

All this will not be accomplished overnight. It is not the work of days, or years or decades. It is the work of generations. And our generation has made a promising beginning.

Today there is a whole generation of people on our planet who never believed that going to the moon would be impossible. Tomorrow there will be people living, working and learning in space and they and we will accept this evolutionary step for mankind as a routine development. Still later, there probably will be people who will be totally comfortable with the world they have created for themselves on other bodies of the solar system.

The playwright Tennessee Williams once wrote: "The future is called 'perhaps,' which is the only possible thing to call the future. And the important thing is not to allow that to scare you."

Indeed, if we ceased to look outward and reach forward because we fear the future, we would never realize the promise of new knowledge and its enormous potential for human development.

History offers many trenchant examples of what happens when the urge to explore and the development of new technology are forcibly curtailed. One of the most dramatic and far-reaching happened in China during the Ming Dynasty.

In the early years of the 15th century an Admiral and courtier named Cheng Lo mounted a number of great voyages of discovery and trade around the rim of the Indian Ocean, including the East Coast of Africa.

These expeditions were enormous enterprises, using the very best technology available. Each of Cheng Lo's so-called "treasure ships" displaced about 1,500 tons and carried a crew of 500. The largest was 450 feet long, as compared to Columbus' Santa Maria, which was 125 feet in length.

Between 1405 and 1433, the Chinese sent out seven expeditions of this kind. Clearly, their ships had the technical capacity to go around the Cape of Good Hope to West Africa and to Europe as well. But they did not. All of this exploration and enterprise was halted as quickly as it began. Twelve years after the death of Ming Emperor Yung-lo in 1424, his successor issued an edict which not only forbade the construction of ships for overseas voyages, but also cut down on the construc-

tion of warships and armaments. By 1550, the Chinese were prohibited from constructing ships with more than two masts, lest they be used to explore the unknown.

The conservative Confucian mandarins had won the battle to prohibit voyages of exploration and development of the technical means to carry them out. But, in the process, they stunted the spirit of exploration and enterprise in China for centuries to come, contributed to the ossification of Chinese science—and even worse—its divorce from technology.

Indeed, a strong case can be made that their actions led ultimately to the domination of China by the Europeans in the 19th century and to the downfall of ancient Chinese civilization.

Hindsight makes it clear that there is a lesson in all of this that is self-evident, and one we dare not ignore. The destruction of the Ming Navy was an extravagance China could ill afford. And just as the navy was the most visible symbol of the early Chinese commitment to science, technology, new ideas and progress, so our enterprise in space is the modern example of ours.

Continued exploration and development of space holds the promise of a new era of progress, peace and prosperity for all mankind. I believe that promise is unlimited. If we can preserve the peace and build on the existing foundation of international understanding and cooperation on earth and in space, we will have the opportunity to build an enduring world order—a golden age such as history has never known.